

## **CLAIMS**

1. A valve timing control device for an internal combustion engine comprising:

a driving rotational member driven by a crankshaft of the engine;

an engine valve provided at an associated one of an intake port and an exhaust port for opening and closing the associated port;

a valve spring biasing the engine valve in a direction closing of the associated port of the intake and exhaust ports;

a driven rotational member including either one of a camshaft having a cam that opens the engine valve against a spring bias of the valve spring and a separate member integrally connected to and separable from the camshaft; and

an installation-angle adjusting mechanism disposed between the driving rotational member and the driven rotational member to transmit a torque of the driving rotational member to the driven rotational member, the installation-angle adjusting mechanism comprising a movable operating member that varies a relative-rotation phase between the crankshaft and the camshaft by moving the movable operating member in a radial direction of the camshaft by an electromagnetic force depending on engine operating conditions.

2. A valve timing control device for an internal combustion engine as claimed in claim 1, wherein the installation-angle adjusting mechanism transmits the torque of the driving rotational member to the driven rotational member by converting a rotational movement produced depending on the engine operating conditions into a radial displacement and further converting the radial displacement into another rotational movement.

3. A valve timing control device for an internal combustion engine as claimed in claim 2, wherein the rotational movement produced depending on the engine operating conditions is created by an electromagnetic brake.

4. A valve timing control device for an internal combustion engine as claimed in claim 3, wherein the installation-angle adjusting mechanism further comprises a restricting mechanism that restricts the radial displacement of the movable operating member in the radial direction of the camshaft when a relative-rotation phase between the driving rotational member and the driven rotational member reaches a predetermined value.

5. A valve timing control device for an internal combustion engine as claimed in claim 4, wherein the restricting mechanism comprises a stopper that an end portion of the movable operating member is brought into abutted-engagement with the stopper when the relative-rotation phase between the driving rotational member and the driven rotational member reaches a substantially maximum value.

6. A valve timing control device for an internal combustion engine as claimed in claim 4, wherein the restricting mechanism comprises a stopper that a connected end portion of the link is brought into abutted-engagement with the stopper when the relative-rotation phase between the driving rotational member and the driven rotational member reaches a substantially maximum value.

7. A valve timing control device for an internal combustion engine as claimed in claim 5, which further comprises a cushioning mechanism provided at the stopper or a member which is brought into abutted-engagement with the stopper.

8. A valve timing control device for an internal combustion engine as claimed in claim 6, which further comprises a cushioning mechanism provided at the stopper or a member which is brought into abutted-engagement with the stopper.

9. A valve timing control device for an internal combustion engine comprising:

- a driving rotational member driven by a crankshaft of the engine;

- an engine valve provided at an associated one of an intake port and an exhaust port for opening and closing the associated port;

- a valve spring biasing the engine valve in a direction closing of the associated port of the intake and exhaust ports;

- a driven rotational member including either one of a camshaft having a cam that opens the engine valve against a spring bias of the valve spring and a separate member integrally connected to and separable from the camshaft;

- an installation-angle adjusting mechanism disposed between the driving rotational member and the driven rotational member to transmit a torque of the driving rotational member to the driven rotational member, the installation-angle adjusting mechanism comprising a movable operating member that varies a relative-rotation phase between the crankshaft and the camshaft by way of movement of the movable operating member in a radial direction of the camshaft depending on engine operating conditions; and

- the installation-angle adjusting mechanism comprising:

- a radial guide provided at either one of the driving rotational member and the driven rotational member for guiding the movable operating member and extending in a radial direction of the one rotational member;

- a guide plate provided to be rotatable relative to the driving rotational member and the driven rotational member, and having a spiral guide

that guides the movable operating member and is formed spirally from an outer periphery of the guide plate to an axis of the guide plate, and producing relative rotation of the spiral guide to the radial guide by an electromagnetic force depending on the engine operating conditions; and

a link provided between the movable operating member and the driven rotational member and transmitting a motion to the driven rotational member while converting a radial displacement of the movable operating member in the radial direction of the camshaft into a rotational movement of the camshaft.

10. A valve timing control device for an internal combustion engine as claimed in claim 9, which further comprises an electromagnetic brake that moves the movable operating member in the radial direction of the camshaft by braking the spiral guide rotating and thus rotating the spiral guide relative to the radial guide.

11. A valve timing control device for an internal combustion engine as claimed in claim 10, wherein the installation-angle adjusting mechanism further comprises a restricting mechanism that restricts the radial displacement of the movable operating member in the radial direction of the camshaft when a relative-rotation phase between the driving rotational member and the driven rotational member reaches a predetermined value.

12. A valve timing control device for an internal combustion engine as claimed in claim 11, wherein the restricting mechanism comprises a stopper that an end portion of the movable operating member is brought into abutted-engagement with the stopper when the relative-rotation phase between the driving rotational member and the driven rotational member reaches a substantially maximum value.

13. A valve timing control device for an internal combustion engine as claimed in claim 11, wherein the restricting mechanism comprises a stopper that a connected end portion of the link is brought into abutted-engagement with the stopper when the relative-rotation phase between the driving rotational member and the driven rotational member reaches a substantially maximum value.

14. A valve timing control device for an internal combustion engine as claimed in claim 12, which further comprises a cushioning mechanism provided at the stopper or a member which is brought into abutted-engagement with the stopper.

15. A valve timing control device for an internal combustion engine as claimed in claim 13, which further comprises a cushioning mechanism provided at the stopper or a member which is brought into abutted-engagement with the stopper.

16. A valve timing control device for an internal combustion engine as claimed in claim 10, wherein the electromagnetic brake comprises a first electromagnetic brake and a second electromagnetic brake that accelerates and decelerates rotary motion of the guide plate by controlling energizing and de-energizing of each of the first and second electromagnetic brakes.

17. A valve timing control device for an internal combustion engine as claimed in claim 10, wherein the electromagnetic brake comprises a friction material that is brought directly or indirectly into contact with the guide plate by energizing the electromagnetic brake.

18. A method for changing a valve timing of an internal combustion engine employing a driving rotational member driven by a crankshaft of the engine, a driven rotational member including either one of a camshaft and a separate member integrally connected to and separable from the camshaft, and a phase-angle changing mechanism disposed between the driving rotational member and the driven rotational member for transmitting a torque of the driving rotational member to the driven rotational member and for varying a relative-rotation phase between the crankshaft and the camshaft depending on engine operating conditions, the method comprising:

converting a rotational movement produced by an electromagnetic force depending on the engine operating conditions into a radial displacement; and

further converting the radial displacement into a rotational movement of the camshaft to produce relative rotation between the driving rotational member and the driven rotational member.